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Editorial: Women in science: volcanology 2022

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Editorial on the Research Topic
Women in science: volcanology 2022

Introduction

Volcanology is the scientific study of volcanoes, volcanic activity, related phenomena, and impacts on society. Volcanologists - scientists who specialise in this field - examine the processes and features associated with volcanoes, including their formation, eruption mechanisms, solid products, airborne emissions, and the impact of volcanic activity on the surrounding environment and people. The entire breadth of volcanology involves various scientific disciplines such as geology, geochemistry, igneous and experimental petrology, geophysics, computational modelling, atmospheric sciences, monitoring and forecasting, remote sensing, social sciences, hazard and risk assessment/management, assessment of human and animal health effects, epidemiology, clinical studies, toxicology and risk communication. The information gathered by volcanologists helps in monitoring and forecasting volcanic eruptions, assessing risks to nearby populations, and developing strategies for mitigating the impact of volcanic activity on communities and the environment. Understanding volcanology is crucial for managing volcanic hazards and ensuring the safety of people living in volcanic regions.

Under-representation of women working in the geosciences is a global and persistent problem. Membership of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), the American Geophysical Union Volcanology, Geochemistry & Petrology (AGU-VGP) section and the European Geosciences Union Geochemistry-Mineralogy-Petrology-Volcanology (EGU-GMPV) division in 2021 was between 31% and 39% women, with some countries having zero female membership. Early-career women volcanologists comprise 46% and 44% of AGU-VGP and EGU-GMPV, respectively (Kavanagh et al., 2022). Despite increasing numbers of early-career women in volcanology, the lack of senior women and the lack of recognition and celebration of women in awards and medals (e.g., 5% women recipients of the AGU Bowen Award since 1981: Kavanagh et al., 2022) suggests that gender inequality exists in volcanology and that it intensifies at higher career stages. Retention of women within the geosciences profession is a particular

challenge. For example, while over 40% of doctoral degrees in geosciences in the United States of America are earned by women, they occupy less than 10% of full-time professional positions roles in the field (Dutt et al., 2016). The role of women is vital for fostering a more equitable, diverse, and inclusive volcanology community.

With this Research Topic, we aimed to promote the work of women scientists within volcanology, with the intention of highlighting and celebrating the diversity of research led by women across the entire breadth of volcanology. The issue is a tribute to women working in volcanology, and a reminder of the contributions that women researchers make that shape and enrich the field of volcanology. It also serves as a reminder of the difficulties that some of us still face today.

For this Research Topic, we encouraged a range of article types including Original Research, Methods, and Perspective articles reflecting on career pathways, highlights, obstacles and how these were overcome. We have tried to cover a large range of key topics in volcanology from science research and operational papers, to career retrospectives. Four articles within this Research Topic are dedicated to retrospectives of the paths, challenges and successes that women and women-led initiatives have taken in volcanology. These act as inspiring storylines for the many paths that can be taken to succeed as a woman in volcanology.

Our Research Topic consists of 13 articles, all led by women, and representing a total of 55 authors, three-quarters of whom are women. At the time of writing this editorial, the Research Topic had reached 24,500 views and 3,135 article downloads.

A brief summary of each article type is given below with the mention of the current position of the female lead author.

Science research papers

Social sciences

Bartel and Naismith applied qualitative social science methods to investigate women's experiences of evacuations at Fuego volcano, Guatemala. Their study is of importance not only to volcanology, but more generally to disaster risk reduction, by providing a grounded example of understanding how gendered experiences of evacuation can inform future DRR efforts. Beth Bartel is a Mendenhall postdoctoral fellow with the US Geological Survey at the Cascades Volcano Observatory.

Chim et al. investigate the impact of the COVID-19 pandemic on volcanology researchers, particularly early career researchers (ECRs) and those with disabilities, through a global survey conducted from January to March 2023. Their findings reveal that a significant proportion of volcanology researchers continue to face challenges from the pandemic, with ECRs and disabled researchers experiencing disproportionate impacts. Over half of the surveyed researchers have either left or considered leaving academia due to pandemic-related factors. The study gives recommendations for targeted efforts to support these groups and mitigate long-term impacts, urging the research community to foster inclusivity and address persistent issues including gender and racial biases within the volcanology community. By doing so, the field of Volcanology can better navigate future disruptions and promote equity among researchers. May Chim is currently a PhD student at the University of Cambridge, UK.

Physical science

Widiwijayanti et al. underline how crucial monitoring volcanoes is for hazard mitigation to protect lives and economies. Technological advancements have greatly improved our understanding of volcanic processes. Modern monitoring now combines ground-based methods with remote and space-based techniques like satellite sensing and infrasound. Effective monitoring requires careful planning of infrastructure, including sensor networks, data transmission, and power supply, tailored to each volcano's needs. In this article, it has been shown how essential it is to collaborate with the global scientific community. Indeed, the authors have created a Global Volcano Monitoring Infrastructure Database (GVMID) to compile data on volcano monitoring systems worldwide. GVMID helps improve monitoring setups, shares insights on new technologies, and identifies gaps in current systems. Christina Widiwijayanti is a Senior Research Fellow, from the Volcano Group of the Earth Observatory of Singapore.

Dupont De Dinechin et al. focus on understanding degassing during magma ascent in deciphering links between petrological and monitoring data in order to better assess volcanic hazards. Lithium (Li) has been used to track magmatic and post-eruptive processes due to its high mobility in silicate melts and crystals, but its application requires more data. This review focuses on Li behavior in felsic magmas (andesitic to rhyolitic), which are poorly understood in explosive eruptions. It highlights current knowledge, challenges in interpreting Li data, and suggests future research directions. Maylis Dupont de Dinechin is a PhD student at l'Institut des Sciences de la Terre de Paris (ISTeP), Sorbonne University, France.

Metcalfe et al. discuss the importance of volatiles in volcanic activity, as their behaviour is key to understanding volcanic processes. This study focuses on melt inclusion data from La Soufrière de Guadeloupe, a volcano in the Lesser Antilles that has experienced increased activity since 1992. The goal of this study is to examine degassing processes and the environmental effects of sulfur emissions after four main different eruptions. Data show a systematic decrease in sulfur content over time, suggesting the system is evolving as FeS separates. The degassing likely occurs mostly during magma ascent. The study also quantifies sulfur dioxide (SO_2) emissions using the petrologic method. While the smaller eruptions had minimal emissions, the Plinian ones produced significant SO_2 emissions, comparable to those of the 1902 Montagne Pelée and 1979 Soufrière St. Vincent eruptions. Modeling shows these emissions contribute to a small but cumulative effect on climate forcing. Abigail Metcalfe is a post-doctoral fellow at Laboratoire Magmas et Volcans (Clermont-Ferrand, France) working in the volcanological group.

Vivieros et al. assess the risk posed by soil CO_2 degassing in volcanic areas, particularly in villages within the Azores archipelago, where high concentrations of indoor CO_2 have been recorded. Using a combination of susceptibility, exposure, and vulnerability maps, the study assesses the risk of CO_2 exposure in two villages on São Miguel Island, Azores, revealing that a significant percentage of buildings are at high risk. The research proposes criteria for producing risk maps of indoor CO_2 exposure based on diffuse degassing areas, aiming to mitigate potential hazards for the exposed population. Mitigation strategies include implementing gas-resistant building codes, ventilation systems, and real-time monitoring and alarm systems to reduce the risk of CO_2 exposure

in affected areas. Fátima Viveiros is currently an Associate Professor at the Institute for Research in Vulcanology and Risk Assessment, University of the Azores Ponta Delgada, Portugal.

Furst et al. investigates whether eruptions are reliable precursors to marine volcano collapses, as most marine collapses have occurred at erupting volcanoes. The eruption chronologies of historical marine volcano collapses from 1600 CE onwards were assessed to identify whether collapses exhibit reliable and robust precursors that could be used in forecasting. Séverine Furst is a postdoctoral researcher in the Marine Geodynamics research unit of GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany.

Burgos et al. applied agglomerative hierarchical clustering to identify analogue volcanoes, using a newly compiled global dataset of volcanological characteristics. The novel approach groups volcanoes with similar attributes and reduces the uncertainty in determining future eruption probabilities at data-limited volcanoes. In this study, it was used to derive a frequency-magnitude relationship for Melimoyu volcano, a long-dormant volcano in the Southern Volcanic Zone (SVZ) of Chile. Vanesa Burgos is a post-doctoral fellow at the Geophysical Institute, University of Alaska Fairbanks, United States.

Jenkins et al. add to the very limited empirical data on tephra fall impacts, presenting the results of a field survey of 589 buildings affected during the 2018 eruption of Manaro Voui, Ambae, Vanuatu. This represents the first volcanic damage assessment for traditional (thatched timber) buildings that are prevalent across the South Pacific and parts of Asia. They found traditional buildings to be the least resistant to tephra loading, with some collapsing under ~40 mm thickness while others sustained no damage under >200 mm. Pre-eruption building condition and mitigation (e.g., covering roofs with tarpaulins, propping the main roof beam) affected the thickness at which damage occurred. Findings can be used to calibrate fragility functions and improve impact forecasts. Susanna Jenkins is an Associate Professor at Nanyang Technological University, Singapore.

Career retrospectives

Horwell et al. detail how over the past 20 years, the International Volcanic Health Hazard Network (www.ivhhn.org) has evolved from a discussion forum for scientists and practitioners working on protecting communities from volcanic health hazards, to an international organisation that provides evidence-based information to the public and advises governments on preparing for and responding to volcanic eruptions. Claire Horwell is a Professor of Geohealth at Durham University, England, and is the founder and Director of IVHHN.

Lindsay describes her research path from fundamental petrology to more applied research as she progressed from student to Professor. The paper highlights the work of PhD student research to reinforce the point that "my success is not mine alone but based on the success of many", while also describing the opportunities and challenges along the path. Jan Linsday is a professor in the School of Environment at University of Auckland, Aotearoa New Zealand and is Aotearoa New Zealand's only female professor of volcanology.

Jolly, in this essay, reflects on her career and the scientists who have inspired her work. She shares key lessons learned as a woman in science and highlights positive changes in volcanology and science over the past 4 decades. The author expresses optimism for the next-generation of volcanologists to continue advancing the field and improving safety for communities affected by volcanic activity. Gill Jolly is a senior research scientist at GNS Sciences, New Zealand and is currently the Chief Science Advisor to the Ministry of Business, Innovation and Employment for the New Zealand Government.

Driedger et al. details her path from studying glaciers and glaciated volcanoes through to coordinating outreach for the Cascades Volcano Observatory and the USGS. The paper focuses on the importance of developing transdisciplinary and diverse coalitions, which have a common purpose, vested interest, and are based on trust. Such coalitions proved critical for effective research, crisis response, volcanic risk management, and outreach. Carolyn Driedger is Emeritus Outreach Coordinator at the USGS Cascades Volcano Observatory, United States.

In conclusion, the articles in this Research Topic highlight the diversity and excellence of volcanological science led by women researchers, showcasing the significant impact women have made in geoscience. We hope that this Research Topic highlights the contributions of women in volcanology worldwide and serves as a source of inspiration for current and future generations of women and girls, especially those aspiring to enter the field of volcanology.

However, our goal of including contributions from women volcanologists working in low- and middle-income countries was not achieved, with almost all authors coming from well-established institutions in high-income countries. This limitation may stem from the financial and time constraints faced by scientists from developing regions.

While progress has been made in reducing gender biases, prejudices persist, and women in science continue to face obstacles that their male colleagues may not encounter. These barriers can hinder their careers, and ignoring them is a real threat to future progress. It is crucial to remember both the challenges faced by women today and the contributions of past female scientists who paved the way. This Research Topic pays tribute to these pioneering women, acknowledging their role in creating a foundation that allows today's female researchers to pursue their work with passion and dedication in volcanology and Earth Sciences.

Author contributions

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